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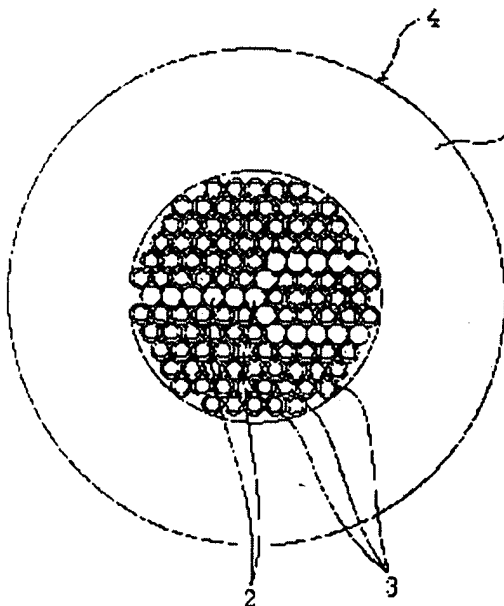
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(54) METHOD FOR MANUFACTURING PHOTONIC CRYSTAL WAVEGUIDE



(57)Abstract:

PROBLEM TO BE SOLVED: To provide a method for manufacturing a photonic crystal waveguide which results in a low production cost and little variance in the characteristics of waveguides even when waveguides of a same structure are mass-produced.

SOLUTION: A first solid rod material 2 and a second rod material 3 having an inner part and an outer part with different refractive indices are prepared in a plurality of pieces for each. The first rod material 2 and the second rod material 3 are bundled to produce a rod bundle 4 in such a manner that the end face of the bundle has a specified waveguide pattern formed by the first rod material 2 and has a specified grating pattern by the inner part of the second material 3. Then the rod material bundle 4 is heated and stretched to decrease the diameter to produce a fiber material. The fiber material is sliced into

specified thickness to produce the photonic crystal waveguide.

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CLAIMS

[Claim(s)]

[Claim 1] The solid 1st rod material and the 2nd rod material which has the inside section and the lateral part from which a refractive index differs mutually, It prepares two or more ***** at a time. the above-mentioned two or more 1st rod material and the two or more 2nd rod material After bundling so that a predetermined waveguide pattern may be formed in a bunch end face by this 1st rod material and a predetermined grid pattern may be formed by the inside section of this 2nd rod material, and producing a rod material bunch, The manufacture method of the photograph nick crystal waveguide characterized by what the above-mentioned rod material bunch is narrow-diameter-ized by heating extension processing, a fibrous object is produced, and a photograph nick crystal waveguide is manufactured for by slicing the above-mentioned fibrous object in predetermined thickness.

[Claim 2] The manufacture method of the photograph nick crystal waveguide according to claim 1 characterized by making the above-mentioned 2nd rod material into a capillary.

[Claim 3] the [the above-mentioned 1st rod material and] -- the manufacture method of the photograph nick crystal waveguide according to claim 1 or 2 characterized by being filled up with 2 rod material in a tubed support pipe, and forming the above-mentioned rod material bunch

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[The technical field to which invention belongs] this invention relates to the manufacture method of a photonic crystal waveguide ("PC (photonic crystal) waveguide" is called below).

[0002]

[Description of the Prior Art] PC waveguide By arranging many dielectric pillars b and b and -- regularly on Substrate a, as shown in drawing 9 (a) Or the field of the photonic crystal structure of changing a refractive index periodically in two dimensions formed by arranging many air rods d and d and -- in glass-plate c regularly as shown in drawing 9 (b), It has the optical waveguide field formed of the defective train enclosed by the photonic crystal structure field. Only the thing of the wavelength confined in the optical waveguide field by the photonic crystal structure field among the light by which incidence was carried out is spread and outputted, and it is known as a device which makes rapid bending of light possible.

[0003] for example, as a PC waveguide of the air rod type shown in drawing 9 (b) The device which divides into two the light which has an optical waveguide field the T junction type which was surrounded by the field of the photonic crystal structure which consisted of air rods as shown in drawing 10 (a) or (b), and was formed, or Y branch-type, There is a resonator of composition as shown in the coupler which has an optical X character-like waveguide field as shown in drawing 10 (c) and (d), drawing 10 (e), and (f) etc.

[0004] Moreover, the function of this PC waveguide has the thing of the structure where the air rod was arranged as it changes with the photonic crystal barrel structures and was shown in drawing 11 (a), for example, so that a tetragonal lattice might be formed, the thing of the structure where the air rod was arranged so that a triangular grid might be formed, as shown in drawing 11 (b), and the thing of the structure where the air rod was arranged so that a honeycomb grid might be formed, as shown in drawing 11 (c)

[0005] And such an air rod type PC waveguide Resist g is applied to the front face, while forming the quartz (SiO₂) layer f on Substrate e, as shown in drawing 12 (a). As shown in drawing 12 (b), after exposing the electron ray by the periodic pattern, Negatives are developed as shown in drawing 12 (c) (electron beam lithography). As shown in drawing 12 (d), the air rods h and h and -- are formed in a part for the outcrop of the quartz (SiO₂) layer f by reactive ion etching, and it is manufactured by finally, removing Resist g, as shown in drawing 12 (e).

[0006] However, by this method, if it is difficult to process the air rod whose diameter is submicron with high precision, for example, the upper part differs in the diameter of an air rod from the lower part, photonic crystal structure will become what does not achieve a predetermined function.

[0007] on the other hand, to JP,11-218627,A After producing the slab optical waveguide which consists of a lower clad layer, a core layer, and an up clad layer on a substrate as the manufacture method of PC waveguide, An electron beam, SOR (synchrotron orbital radiation) light, Either ultraviolet rays or the near infrared rays are alternatively irradiated through an up clad layer at a core layer. What forms a lattice-like high refraction field

and constitutes photograph nick crystal structure by producing the refractive-index change by the optical inductive effect is indicated. by this composition It is indicated that it is a high precision size and the size of each part in the depth direction can manufacture a uniform refractive-index change field (photograph nick crystal structure field).

[0008]

[Problem(s) to be Solved by the Invention] However, any manufacture method of the above-mentioned PC waveguide has the problem of being easy to generate the variation in the property for every PC waveguide, while a manufacturing cost becomes high when mass-producing PC waveguide of the same structure since it becomes the manufacture for every PC waveguide.

[0009] this invention is made in view of this point, and the place made into the purpose is to offer the manufacture method of PC waveguide with the small variation in the property for every PC waveguide with a low and manufacturing cost, even when mass-producing PC waveguide of the same structure.

[0010]

[Means for Solving the Problem] this invention prepares at a time two or more 2nd rod material which has the inside section and the lateral part from which the solid 1st rod material and a solid refractive index differ mutually, respectively. a bunch end face -- the 1st rod material -- a predetermined waveguide pattern -- forming -- the [and] -- a predetermined grid pattern is formed by the inside section of 2 rod material -- as -- the [the 1st rod material and], after bundling 2 rod material and producing a rod material bunch The rod material bunch is narrow-diameter-ized by drawing processing, a fibrous object is produced, and PC waveguide is manufactured by slicing the fibrous object in predetermined thickness.

[0011] this invention is specifically the manufacture method of PC waveguide. The solid 1st rod material, It prepares at a time two or more 2nd rod material which has the inside section and the lateral part from which a refractive index differs mutually, respectively. After bundling so that a predetermined waveguide pattern may be formed in a bunch end face for the above-mentioned two or more 1st rod material and the two or more 2nd rod material by this 1st rod material and a predetermined grid pattern may be formed by the inside section of this 2nd rod material, and producing a rod material bunch, The above-mentioned rod material bunch is narrow-diameter-ized by heating extension processing, a fibrous object is produced, and it is characterized by what a photograph nick crystal waveguide is manufactured for by slicing the above-mentioned fibrous object in predetermined thickness.

[0012] It considers as a fibrous object by carrying out heating extension processing of the rod material bunch constituted by the 1st rod material and the 2nd rod material according to the above-mentioned composition. Since PC waveguide of thousands of - a lot of tens of thousands of same structures can be obtained if PC waveguide will be manufactured and there is a fibrous object also 1m by slicing the fibrous object in thickness of several micrometers - dozens of micrometers A manufacturing cost becomes very low while productivity becomes good compared with the case where it manufactures for every PC waveguide. And since the fibrous object acquired by heating extension processing becomes very very small [the difference of structure] per several m like the optical fiber obtained by carrying out drawing processing of the preforming, the variation in the property for every PC waveguide which slices the same fibrous object and is obtained

becomes very small.

[0013] here, as composition of the 2nd rod material, either the inside section and a lateral part form with the quartz (SiO_2) which added the germanium (germanium) which is the component which raises a refractive index -- having -- and another side -- being pure (SiO_2) -- the formed rod material -- The rod material in which it was formed in with the quartz (SiO_2) which added the fluorine (F) which is the component for which either the inside section and a lateral part reduce a refractive index, and boron (B), and another side was formed with the pure quartz (SiO_2), The rod material formed with the quartz (SiO_2) with which it was formed with the quartz (SiO_2) with which either the inside section and the lateral part added germanium (germanium), and another side added a fluorine (F) and boron (B), The capillary by which it was formed with the quartz (SiO_2) with which the lateral part added germanium (germanium), the quartz (SiO_2) which added a fluorine (F) and boron (B), or the pure quartzes (SiO_2), and the inside section was formed in the hole, It will not be limited especially if it has the inside section and the lateral part from which a refractive index differs mutually. Moreover, the refractive index of the 1st rod material and each refractive index of the inside section of the 2nd rod material and a lateral part have the independent relation, you may have the refractive index from which three persons differ mutually, and the inside section or the lateral part of the 1st rod material and the 2nd rod material may have the same refractive index. Furthermore, especially the cross-section outline configuration of the inside section of the 2nd rod material is not limited [form / ellipse / circular,].

[0014] Moreover, especially as a waveguide pattern, it is not limited and Y branch-type, a T junction type, etc. can be mentioned.

[0015] Furthermore, as a grid pattern, especially if photograph nick crystal structure is constituted after drawing processing, it is not limited, and a triangular grid, a cubic lattice, a honeycomb grid, etc. can be mentioned.

[0016] the [moreover, / the 1st rod material and] -- it is filled up with 2 rod material in a tubed support pipe, and you may make it form a rod material bunch According to this composition, since both rods material will be restrained with a support pipe, movement of each rod material will be regulated and heating extension processing will turn easily.

[0017]

[Effect of the Invention] It considers as a fibrous object by carrying out heating extension processing of the rod material bunch constituted by the 1st rod material and the 2nd rod material according to this invention, as explained above. Since PC waveguide of thousands of - a lot of tens of thousands of same structures can be obtained if PC waveguide will be manufactured and there is a fibrous object also 1m by slicing the fibrous object in thickness of several micrometers - dozens of micrometers A manufacturing cost can be made very low while being able to make productivity good compared with the case where it manufactures for every PC waveguide. And since the fibrous object acquired by heating extension processing becomes very very small [the difference of structure] per several m, variation in the property for every PC waveguide which slices the same fibrous object and is obtained can be made very small.

[0018]

[Embodiments of the Invention] (Operation gestalt 1) A process is hereafter explained later on about the manufacture method of PC waveguide concerning the operation gestalt 1 of this invention.

[0019] The solid rod (the 1st rod material) of the shape of 1 and a pillar made from a quartz (SiO_2) is prepared for the support pipe of the shape of a cylinder made from a <preparation process> quartz (SiO_2), and two or more are prepared for the capillary (the 2nd rod material) of the shape of two or more and a cylinder made from a quartz (SiO_2). Here, a capillary and a solid rod are the same outer diameters. Moreover, a lateral part is formed with a quartz (SiO_2), a refractive index is relatively high, and the inside section is formed in a hole, and, as for the capillary, the refractive index has low composition relatively.

[0020] it is shown in <rod fasciculation process> drawing 1 -- as -- the inside of the support pipe 1 -- the medial axis of the support pipe 1, and parallel -- the solid rods 2 and 2, -- and capillaries 3 and 3, and -- the maximum -- **** -- the rod material bunch 4 is produced by being filled up While the solid rods 2 and 2 and -- form a Y branch-type waveguide pattern in a bunch end face at this time, capillaries 3 and 3 and the hole of -- form a triangular grid pattern in the remaining fields. Moreover, the solid rods 2 and 2 and -- which are located in an outermost layer of drum and capillaries 3 and 3, and -- and the gap produced between the walls of the support pipe 1 are filled up with fillers, such as SiO_2 powder, and it is made for those position gaps not to arise.

[0021] The fibrous object 5 which carried out heating extension and narrow-diameter-ized the <heating extension process> rod material bunch 4 fibrous is produced. At this time, solid rod 2 adjoining comrades, capillary 3 comrades, the solid rod 2, a capillary 3 and the solid rod 2 located in an outermost layer of drum, and a capillary 3 and the support pipe 1 will carry out weld unification mutually. As shown in drawing 2, the fibrous object 5 produced by carrying out heating extension of the rod material bunch 4 is constituted by the wrap covering section 7 in Y branch-type solid section 6a and the capillaries 3 and 3 which were formed of the solid rods 2 and 2 and --, the pores 6b and 6b of a large number formed of --, the waveguide formation section 6 which consists of --, and the waveguide formation section 6 formed with the support pipe 1.

[0022] As shown in <slice process> drawing 3, subsequently to the thickness of several micrometers - dozens of micrometers, the fibrous object 5 is sliced by processing it into a prismatic by using the cutter for precision processing etc., and the waveguide main part 8 is produced. And solvents (ethanol, an acetone, dichloromethane, etc.) wash the sliced waveguide main part 8, and cutting waste is removed. At this time, it replaces with washing with a solvent, or, in addition to washing with a solvent, may be made to perform ultrasonic cleaning. Thus, the manufactured waveguide main part 8 is constituted in two dimensions by the photograph nick crystal structure field 10 which was arranged so that the air rods 10a and 10a corresponding to the optical-waveguide field 9 formed in the Y branch-type defective train corresponding to solid section 6a of the fibrous object 6 and pore 6b of the fibrous object 6 and -- might form a triangular grid and where a refractive index is changed periodically.

[0023] As shown in <upper part and lower clad arrangement process> drawing 4, the PC waveguide 13 as a device which divides a Y branch-type light into two is constituted by making it insert and unify by the up clad 11 and the lower clad 12 which were formed with the quartz (SiO_2) board which added the fluorine (F) which is the component for which the waveguide main part 8 reduces a refractive index respectively, and boron (B). What is necessary is making it just make each of the waveguide main part 8, the up clad 11, and the lower clad 12 unify using adhesives at this time. As for adhesives, what has a

refractive index of the same grade as the quartz (SiO_2) which added the fluorine (F) which constitutes the quartz (SiO_2) or the up clad 11, and the lower clad 12 which constitute the waveguide main part 8, and boron (B) is desirable, for example, commercial ultraviolet-rays hardening type resin adhesives can be used suitably.

[0024] It considers as the fibrous object 5 by carrying out heating extension processing of the solid rods 2 and 2, and capillaries 3 and 3 and the rod material bunch 4 constituted by -- according to the manufacture method of the PC waveguide 13 of the above-mentioned composition. [--, and] The PC waveguide 13 will be manufactured from the waveguide main part 8 sliced in thickness of several micrometers - dozens of micrometers after processing the fibrous object 5 into a prismatic. A manufacturing cost becomes very low, while productivity becomes good compared with the case where it manufactures for every PC waveguide, since the PC waveguide 13 of thousands of - a lot of tens of thousands of same structures can be obtained if there is a fibrous object 5 also 1m. And since the fibrous object 5 acquired by heating extension processing becomes very very small [the difference of structure] per several m like the optical fiber obtained by carrying out drawing processing of the preforming, the variation in the property for every PC waveguide 13 which slices the same fibrous object 5 and is obtained becomes very small.

[0025] Moreover, since it is filled up with the solid rods 2 and 2, -- and capillaries 3 and 3, and -- in the tubed support pipe 1 and is made to form the rod material bunch 4, both the rods material 2 and 3 will be restrained with the support pipe 1, movement of each rod material 2 and 3 will be regulated, and heating extension processing will turn easily.

[0026] In addition, although the Y branch-type waveguide pattern was formed with the solid rod 2 with the above-mentioned operation gestalt 1, you may be what is not limited to especially this and formed the T junction type and the X character-like waveguide pattern.

[0027] Moreover, although the air rods 10a and 10a and the PC waveguide 13 arranged so that -- might form a triangular grid were manufactured with the above-mentioned operation gestalt 1 by bundling capillaries 3 and 3 and -- in the shape of maximum dense, it is not limited to especially this, and you may arrange by operating a setup of the gestalt of a capillary bunch so that an air rod may form a tetragonal lattice and a honeycomb grid. In this case, since neither a tetragonal-lattice pattern nor a honeycomb grid pattern is formed depending on the closest packing of a capillary, gestalt maintenance of a grid pattern can be aimed at by being filled up with fillers, such as a quartz rod, between capillaries.

[0028] Moreover, although the capillary 3 was used with the above-mentioned operation gestalt 1 as the 2nd rod material which has the inside section and the lateral part from which a refractive index differs mutually The capillary by which it was formed with the quartz (SiO_2) which added the quartz (SiO_2) or fluorine (F) with which not the thing limited to especially this but the lateral part added germanium (germanium), and boron (B), and the inside section was formed in the hole, either the inside section and a lateral part form with the quartz (SiO_2) which added the germanium (germanium) which is the component which raises a refractive index -- having -- and another side -- being pure (SiO_2) -- the formed rod material -- The rod material in which it was formed in with the quartz (SiO_2) which added the fluorine (F) which is the component for which either the inside section and a lateral part reduce a refractive index, and boron (B), and another side

was formed with the pure quartz (SiO_2), You may be the rod material formed with the quartz (SiO_2) with which it was formed with the quartz (SiO_2) with which either the inside section and the lateral part added germanium (germanium), and another side added a fluorine (F) and boron (B).

[0029] Moreover, although the solid rod 2 was made pure made from the quartz (SiO_2) with the above-mentioned operation gestalt 1, you may be the thing made from a quartz (SiO_2) which added the fluorine (F) which is the component for which the thing and refractive index made from the quartz (SiO_2) which added the germanium (germanium) which is the component which raises a refractive index are reduced, and boron (B).

[0030] Moreover, although it was sliced and the waveguide main part 8 was produced with the above-mentioned operation gestalt 1 after processing the fibrous object 5 into a prismatic, the fibrous object 5 is sliced, the disk-like object 14 is created, and you may make it cut down the waveguide main part 8 of a rectangle tabular from the core first, as it is not limited to especially this and shown in drawing 5 . However, the method of productivity shown with the operation gestalt 1 becomes good and is more desirable.

[0031] Moreover, although it was made to unify on both sides of the waveguide main part 8 with the above-mentioned operation gestalt 1 by the upper part and the lower clad 11 and 12, this is for making handling nature of the PC waveguide 13 good, and is not an indispensable component as a PC waveguide.

[0032] (Operation gestalt 2) By the same manufacture method as the operation gestalt 1, the waveguide main part of various kinds of waveguide patterns as shown in drawing 10 (a) - (f) is produced.

[0033] And as shown in drawing 6 , make each waveguide main part 8 into one unit, and it arranges combining the waveguide main parts 8 and 8 and -- which have a predetermined waveguide pattern on the bottom substrate 15 formed with the quartz (SiO_2) board which added a fluorine (F) and boron (B). By putting a top substrate from moreover, large-sized PC waveguide with which the waveguide pattern of each waveguide main part 8 was connected is constituted. At this time, as shown in drawing 7 , the waveguide main parts 8 and 8 which adjoin mutually based on the markers 16 and 16 for alignment prepared in the place which does not have optical influence on an optical waveguide field 9 like the corner of the waveguide main part 8 are arranged, and those position gaps are prevented. What is necessary is for colored glass, an air hole (hole), a quartz pillar, etc. just to constitute this marker 16. If it is the waveguide main part 8 which a photograph nick crystal structure field consists of with an air rod, an air rod or an optical waveguide field may serve as a marker 16. Moreover, incidence of the light is carried out from the waveguide edge of one waveguide main part 8, and like the power monitor method at the time of making weld connection of the optical fiber, it may be made to perform alignment instead of a marker so that the outgoing radiation light intensity in the waveguide edge of the waveguide main part of another side may serve as the maximum. In addition, adhesion unification is carried out by the method as the operation gestalt 1 that each of each waveguide main part 8, a top substrate, and the bottom substrate 15 is the same.

[0034] (Operation gestalt 3) Two or more waveguide main parts of a homotypic or different species are produced by the same manufacture method as the operation gestalt 1.

[0035] And as shown in drawing 8 , the 3-dimensional PC waveguide 13 is constituted by carrying out a laminating in two or more of those waveguide main parts 8 and 8 and --. In

addition, the adhesion unification of the waveguide main part 8 comrades is carried out by the same method as the operation gestalt 1.

[Translation done.]

TECHNICAL FIELD

[The technical field to which invention belongs] this invention relates to the manufacture method of a photograph nick crystal waveguide ("PC (photonic crystal) waveguide" is called below).

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* NOTICES *

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PRIOR ART

[Description of the Prior Art] PC waveguide By arranging many dielectric pillars b and b and -- regularly on Substrate a, as shown in drawing 9 (a) Or the field of the photograph nick crystal structure of changing a refractive index periodically in two dimensions formed by arranging many air rods d and d and -- in glass-plate c regularly as shown in drawing 9 (b), It has the optical waveguide field formed of the defective train enclosed by the photograph nick crystal structure field. Only the thing of the wavelength confined in the optical waveguide field by the photograph nick crystal structure field among the light by which incidence was carried out is spread and outputted, and it is known as a device which makes rapid bending of light possible.

[0003] for example, as a PC waveguide of the air rod type shown in drawing 9 (b) The device which divides into two the light which has an optical waveguide field the T junction type which was surrounded by the field of the photograph nick crystal structure which consisted of air rods as shown in drawing 10 (a) or (b), and was formed, or Y branch-type, There is a resonator of composition as shown in the coupler which has an optical X character-like waveguide field as shown in drawing 10 (c) and (d), drawing 10 (e), and (f) etc.

[0004] Moreover, the function of this PC waveguide has the thing of the structure where the air rod was arranged as it changes with the photograph NIKUKURISU barrel structures and was shown in drawing 11 (a), for example, so that a tetragonal lattice

might be formed, the thing of the structure where the air rod was arranged so that a triangular grid might be formed, as shown in drawing 11 (b), and the thing of the structure where the air rod was arranged so that a honeycomb grid might be formed, as shown in drawing 11 (c)

[0005] And such an air rod type PC waveguide Resist g is applied to the front face, while forming the quartz (SiO₂) layer f on Substrate e, as shown in drawing 12 (a). As shown in drawing 12 (b), after exposing the electron ray by the periodic pattern, Negatives are developed as shown in drawing 12 (c) (electron beam lithography). As shown in drawing 12 (d), the air rods h and h and -- are formed in a part for the outcrop of the quartz (SiO₂) layer f by reactive ion etching, and it is manufactured by finally, removing Resist g, as shown in drawing 12 (e).

[0006] However, by this method, if it is difficult to process the air rod whose diameter is submicron with high precision, for example, the upper part differs in the diameter of an air rod from the lower part, photograph nick crystal structure will become what does not achieve a predetermined function.

[0007] on the other hand, to JP,11-218627,A After producing the slab optical waveguide which consists of a lower clad layer, a core layer, and an up clad layer on a substrate as the manufacture method of PC waveguide, An electron beam, SOR (synchrotron orbital radiation) light, Either ultraviolet rays or the near infrared rays are alternatively irradiated through an up clad layer at a core layer. What forms a lattice-like high refraction field and constitutes photograph nick crystal structure by producing the refractive-index change by the optical inductive effect is indicated. by this composition It is indicated that it is a high precision size and the size of each part in the depth direction can manufacture a uniform refractive-index change field (photograph nick crystal structure field).

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EFFECT OF THE INVENTION

[Effect of the Invention] It considers as a fibrous object by carrying out heating extension processing of the rod material bunch constituted by the 1st rod material and the 2nd rod material according to this invention, as explained above. Since PC waveguide of thousands of - a lot of tens of thousands of same structures can be obtained if PC waveguide will be manufactured and there is a fibrous object also 1m by slicing the fibrous object in thickness of several micrometers - dozens of micrometers A manufacturing cost can be made very low while being able to make productivity good

compared with the case where it manufactures for every PC waveguide. And since the fibrous object acquired by heating extension processing becomes very very small [the difference of structure] per several m, variation in the property for every PC waveguide which slices the same fibrous object and is obtained can be made very small.

[0018]

[Embodiments of the Invention] (Operation gestalt 1) A process is hereafter explained later on about the manufacture method of PC waveguide concerning the operation gestalt 1 of this invention.

[0019] The solid rod (the 1st rod material) of the shape of 1 and a pillar made from a quartz (SiO_2) is prepared for the support pipe of the shape of a cylinder made from a <preparation process> quartz (SiO_2), and two or more are prepared for the capillary (the 2nd rod material) of the shape of two or more and a cylinder made from a quartz (SiO_2). Here, a capillary and a solid rod are the same outer diameters. Moreover, a lateral part is formed with a quartz (SiO_2), a refractive index is relatively high, and the inside section is formed in a hole, and, as for the capillary, the refractive index has low composition relatively.

[0020] it is shown in <rod fasciculation process> drawing 1 -- as -- the inside of the support pipe 1 -- the medial axis of the support pipe 1, and parallel -- the solid rods 2 and 2, -- and capillaries 3 and 3, and -- the maximum -- **** -- the rod material bunch 4 is produced by being filled up While the solid rods 2 and 2 and -- form a Y branch-type waveguide pattern in a bunch end face at this time, capillaries 3 and 3 and the hole of -- form a triangular grid pattern in the remaining fields. Moreover, the solid rods 2 and 2 and -- which are located in an outermost layer of drum and capillaries 3 and 3, and -- and the gap produced between the walls of the support pipe 1 are filled up with fillers, such as SiO_2 powder, and it is made for those position gaps not to arise.

[0021] The fibrous object 5 which carried out heating extension and narrow-diameterized the <heating extension process> rod material bunch 4 fibrous is produced. At this time, solid rod 2 adjoining comrades, capillary 3 comrades, the solid rod 2, a capillary 3 and the solid rod 2 located in an outermost layer of drum, and a capillary 3 and the support pipe 1 will carry out weld unification mutually. As shown in drawing 2, the fibrous object 5 produced by carrying out heating extension of the rod material bunch 4 is constituted by the wrap covering section 7 in Y branch-type solid section 6a and the capillaries 3 and 3 which were formed of the solid rods 2 and 2 and --, the pores 6b and 6b of a large number formed of --, the waveguide formation section 6 which consists of --, and the waveguide formation section 6 formed with the support pipe 1.

[0022] As shown in <slice process> drawing 3, subsequently to the thickness of several micrometers - dozens of micrometers, the fibrous object 5 is sliced by processing it into a prismatic by using the cutter for precision processing etc., and the waveguide main part 8 is produced. And solvents (ethanol, an acetone, dichloromethane, etc.) wash the sliced waveguide main part 8, and cutting waste is removed. At this time, it replaces with washing with a solvent, or, in addition to washing with a solvent, may be made to perform ultrasonic cleaning. Thus, the manufactured waveguide main part 8 is constituted in two dimensions by the photograph nick crystal structure field 10 which was arranged so that the air rods 10a and 10a corresponding to the optical-waveguide field 9 formed in the Y branch-type defective train corresponding to solid section 6a of the fibrous object 6 and pore 6b of the fibrous object 6 and -- might form a triangular grid and where a

refractive index is changed periodically.

[0023] As shown in <upper part and lower clad arrangement process> drawing 4, the PC waveguide 13 as a device which divides a Y branch-type light into two is constituted by making it insert and unify by the up clad 11 and the lower clad 12 which were formed with the quartz (SiO_2) board which added the fluorine (F) which is the component for which the waveguide main part 8 reduces a refractive index respectively, and boron (B). What is necessary is making it just make each of the waveguide main part 8, the up clad 11, and the lower clad 12 unify using adhesives at this time. As for adhesives, what has a refractive index of the same grade as the quartz (SiO_2) which added the fluorine (F) which constitutes the quartz (SiO_2) or the up clad 11, and the lower clad 12 which constitute the waveguide main part 8, and boron (B) is desirable, for example, commercial ultraviolet-rays hardening type resin adhesives can be used suitably.

[0024] It considers as the fibrous object 5 by carrying out heating extension processing of the solid rods 2 and 2, and capillaries 3 and 3 and the rod material bunch 4 constituted by -- according to the manufacture method of the PC waveguide 13 of the above-mentioned composition. [--, and] The PC waveguide 13 will be manufactured from the waveguide main part 8 sliced in thickness of several micrometers - dozens of micrometers after processing the fibrous object 5 into a prismatic. A manufacturing cost becomes very low, while productivity becomes good compared with the case where it manufactures for every PC waveguide, since the PC waveguide 13 of thousands of - a lot of tens of thousands of same structures can be obtained if there is a fibrous object 5 also 1m. And since the fibrous object 5 acquired by heating extension processing becomes very very small [the difference of structure] per several m like the optical fiber obtained by carrying out drawing processing of the preforming, the variation in the property for every PC waveguide 13 which slices the same fibrous object 5 and is obtained becomes very small.

[0025] Moreover, since it is filled up with the solid rods 2 and 2, -- and capillaries 3 and 3, and -- in the tubed support pipe 1 and is made to form the rod material bunch 4, both the rods material 2 and 3 will be restrained with the support pipe 1, movement of each rod material 2 and 3 will be regulated, and heating extension processing will turn easily.

[0026] In addition, although the Y branch-type waveguide pattern was formed with the solid rod 2 with the above-mentioned operation gestalt 1, you may be what is not limited to especially this and formed the T junction type and the X character-like waveguide pattern.

[0027] Moreover, although the air rods 10a and 10a and the PC waveguide 13 arranged so that -- might form a triangular grid were manufactured with the above-mentioned operation gestalt 1 by bundling capillaries 3 and 3 and -- in the shape of maximum dense, it is not limited to especially this, and you may arrange by operating a setup of the gestalt of a capillary bunch so that an air rod may form a tetragonal lattice and a honeycomb grid. In this case, since neither a tetragonal-lattice pattern nor a honeycomb grid pattern is formed depending on the closest packing of a capillary, gestalt maintenance of a grid pattern can be aimed at by being filled up with fillers, such as a quartz rod, between capillaries.

[0028] Moreover, although the capillary 3 was used with the above-mentioned operation gestalt 1 as the 2nd rod material which has the inside section and the lateral part from which a refractive index differs mutually The capillary by which it was formed with the

quartz (SiO₂) which added the quartz (SiO₂) or fluorine (F) with which not the thing limited to especially this but the lateral part added germanium (germanium), and boron (B), and the inside section was formed in the hole, either the inside section and a lateral part form with the quartz (SiO₂) which added the germanium (germanium) which is the component which raises a refractive index -- having -- and another side -- being pure (SiO₂) -- the formed rod material -- The rod material in which it was formed in with the quartz (SiO₂) which added the fluorine (F) which is the component for which either the inside section and a lateral part reduce a refractive index, and boron (B), and another side was formed with the pure quartz (SiO₂), You may be the rod material formed with the quartz (SiO₂) with which it was formed with the quartz (SiO₂) with which either the inside section and the lateral part added germanium (germanium), and another side added a fluorine (F) and boron (B).

[0029] Moreover, although the solid rod 2 was made pure made from the quartz (SiO₂) with the above-mentioned operation gestalt 1, you may be the thing made from a quartz (SiO₂) which added the fluorine (F) which is the component for which the thing and refractive index made from the quartz (SiO₂) which added the germanium (germanium) which is the component which raises a refractive index are reduced, and boron (B).

[0030] Moreover, although it was sliced and the waveguide main part 8 was produced with the above-mentioned operation gestalt 1 after processing the fibrous object 5 into a prismatic, the fibrous object 5 is sliced, the disk-like object 14 is created, and you may make it cut down the waveguide main part 8 of a rectangle tabular from the core first, as it is not limited to especially this and shown in drawing 5 . However, the method of productivity shown with the operation gestalt 1 becomes good and is more desirable.

[0031] Moreover, although it was made to unify on both sides of the waveguide main part 8 with the above-mentioned operation gestalt 1 by the upper part and the lower clad 11 and 12, this is for making handling nature of the PC waveguide 13 good, and is not an indispensable component as a PC waveguide.

[0032] (Operation gestalt 2) By the same manufacture method as the operation gestalt 1, the waveguide main part of various kinds of waveguide patterns as shown in drawing 10 (a) - (f) is produced.

[0033] And as shown in drawing 6 , make each waveguide main part 8 into one unit, and it arranges combining the waveguide main parts 8 and 8 and -- which have a predetermined waveguide pattern on the bottom substrate 15 formed with the quartz (SiO₂) board which added a fluorine (F) and boron (B). By putting a top substrate from moreover, large-sized PC waveguide with which the waveguide pattern of each waveguide main part 8 was connected is constituted. At this time, as shown in drawing 7 , the waveguide main parts 8 and 8 which adjoin mutually based on the markers 16 and 16 for alignment prepared in the place which does not have optical influence on an optical waveguide field 9 like the corner of the waveguide main part 8 are arranged, and those position gaps are prevented. What is necessary is for colored glass, an air hole (hole), a quartz pillar, etc. just to constitute this marker 16. If it is the waveguide main part 8 which a photograph nick crystal structure field consists of with an air rod, an air rod or an optical waveguide field may serve as a marker 16. Moreover, incidence of the light is carried out from the waveguide edge of one waveguide main part 8, and like the power monitor method at the time of making weld connection of the optical fiber, it may be made to perform alignment instead of a marker so that the outgoing radiation light

intensity in the waveguide edge of the waveguide main part of another side may serve as the maximum. In addition, adhesion unification is carried out by the method as the operation gestalt 1 that each of each waveguide main part 8, a top substrate, and the bottom substrate 15 is the same.

[0034] (Operation gestalt 3) Two or more waveguide main parts of a homotypic or different species are produced by the same manufacture method as the operation gestalt 1.

[0035] And as shown in drawing 8, the 3-dimensional PC waveguide 13 is constituted by carrying out a laminating in two or more of those waveguide main parts 8 and 8 and --. In addition, the adhesion unification of the waveguide main part 8 comrades is carried out by the same method as the operation gestalt 1.

[Translation done.]

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TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] However, any manufacture method of the above-mentioned PC waveguide has the problem of being easy to generate the variation in the property for every PC waveguide, while a manufacturing cost becomes high when mass-producing PC waveguide of the same structure since it becomes the manufacture for every PC waveguide.

[0009] this invention is made in view of this point, and the place made into the purpose is to offer the manufacture method of PC waveguide with the small variation in the property for every PC waveguide with a low and manufacturing cost, even when mass-producing PC waveguide of the same structure.

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MEANS

[Means for Solving the Problem] this invention prepares at a time two or more 2nd rod material which has the inside section and the lateral part from which the solid 1st rod material and a solid refractive index differ mutually, respectively. a bunch end face -- the 1st rod material -- a predetermined waveguide pattern -- forming -- the [and] -- a predetermined grid pattern is formed by the inside section of 2 rod material -- as -- the [the 1st rod material and], after bundling 2 rod material and producing a rod material bunch The rod material bunch is narrow-diameter-ized by drawing processing, a fibrous object is produced, and PC waveguide is manufactured by slicing the fibrous object in predetermined thickness.

[0011] this invention is specifically the manufacture method of PC waveguide. The solid 1st rod material, It prepares at a time two or more 2nd rod material which has the inside section and the lateral part from which a refractive index differs mutually, respectively. After bundling so that a predetermined waveguide pattern may be formed in a bunch end face for the above-mentioned two or more 1st rod material and the two or more 2nd rod material by this 1st rod material and a predetermined grid pattern may be formed by the inside section of this 2nd rod material, and producing a rod material bunch, The above-mentioned rod material bunch is narrow-diameter-ized by heating extension processing, a fibrous object is produced, and it is characterized by what a photograph nick crystal waveguide is manufactured for by slicing the above-mentioned fibrous object in predetermined thickness.

[0012] It considers as a fibrous object by carrying out heating extension processing of the rod material bunch constituted by the 1st rod material and the 2nd rod material according to the above-mentioned composition. Since PC waveguide of thousands of - a lot of tens of thousands of same structures can be obtained if PC waveguide will be manufactured and there is a fibrous object also 1m by slicing the fibrous object in thickness of several micrometers - dozens of micrometers A manufacturing cost becomes very low while productivity becomes good compared with the case where it manufactures for every PC waveguide. And since the fibrous object acquired by heating extension processing becomes very very small [the difference of structure] per several m like the optical fiber obtained by carrying out drawing processing of the preforming, the variation in the property for every PC waveguide which slices the same fibrous object and is obtained becomes very small.

[0013] here, as composition of the 2nd rod material, either the inside section and a lateral part form with the quartz (SiO_2) which added the germanium (germanium) which is the component which raises a refractive index -- having -- and another side -- being pure (SiO_2) -- the formed rod material -- The rod material in which it was formed in with the quartz (SiO_2) which added the fluorine (F) which is the component for which either the inside section and a lateral part reduce a refractive index, and boron (B), and another side was formed with the pure quartz (SiO_2), The rod material formed with the quartz (SiO_2) with which it was formed with the quartz (SiO_2) with which either the inside section and the lateral part added germanium (germanium), and another side added a fluorine (F) and boron (B), The capillary by which it was formed with the quartz (SiO_2) with which the lateral part added germanium (germanium), the quartz (SiO_2) which added a fluorine (F)

and boron (B), or the pure quartzes (SiO_2), and the inside section was formed in the hole, It will not be limited especially if it has the inside section and the lateral part from which a refractive index differs mutually. Moreover, the refractive index of the 1st rod material and each refractive index of the inside section of the 2nd rod material and a lateral part have the independent relation, you may have the refractive index from which three persons differ mutually, and the inside section or the lateral part of the 1st rod material and the 2nd rod material may have the same refractive index. Furthermore, especially the cross-section outline configuration of the inside section of the 2nd rod material is not limited [form / ellipse / circular,].

[0014] Moreover, especially as a waveguide pattern, it is not limited and Y branch-type, a T junction type, etc. can be mentioned.

[0015] Furthermore, as a grid pattern, especially if photograph nick crystal structure is constituted after drawing processing, it is not limited, and a triangular grid, a cubic lattice, a honeycomb grid, etc. can be mentioned.

[0016] the [moreover, / the 1st rod material and] -- it is filled up with 2 rod material in a tubed support pipe, and you may make it form a rod material bunch According to this composition, since both rods material will be restrained with a support pipe, movement of each rod material will be regulated and heating extension processing will turn easily.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is the front view of the bunch end face of a rod material bunch.

[Drawing 2] It is the front view of the fiber end face of a fibrous object.

[Drawing 3] It is explanatory drawing of a slice process.

[Drawing 4] It is the perspective diagram of the photograph nick crystal waveguide manufactured in the operation gestalt 1.

[Drawing 5] It is explanatory drawing of the slice process concerning other operation gestalten.

[Drawing 6] It is explanatory drawing of the manufacture method of the photograph nick crystal waveguide concerning the operation gestalt 2.

[Drawing 7] It is the plan of a photograph nick crystal waveguide.

[Drawing 8] It is explanatory drawing of the manufacture method of the photograph nick crystal waveguide concerning the operation gestalt 3.

[Drawing 9] It is the perspective diagram of photograph nick crystal structure.

[Drawing 10] It is explanatory drawing showing the example of a waveguide pattern of PC waveguide.

[Drawing 11] It is explanatory drawing showing the example of photograph nick crystal structure of PC waveguide.

[Drawing 12] It is explanatory drawing showing the manufacture method of the conventional PC waveguide.

[Description of Notations]

- 1 Support Pipe
- 2 Solid Rod
- 3 Capillary
- 4 Rod Material Bunch
- 5 Fibrous Object
- 6 Waveguide Formation Section
- 6a Solid section
- 6b Pore
- 7 Covering Section
- 8 Disk-like Object
- 8 Waveguide Main Part
- 9 Optical Waveguide Field
- 10 Photograph Nick Crystal Structure Field
- 10a Air rod
- 11 Up Clad
- 12 Lower Clad
- 13 PC Waveguide
- 14 Disk-like Object
- 15 Bottom Substrate
- 16 Marker
- Substrate
- b Dielectric pillar
- c Glass plate
- d Air rod
- e Substrate
- f Quartz layer
- g Resist
- h Air rod

[Translation done.]

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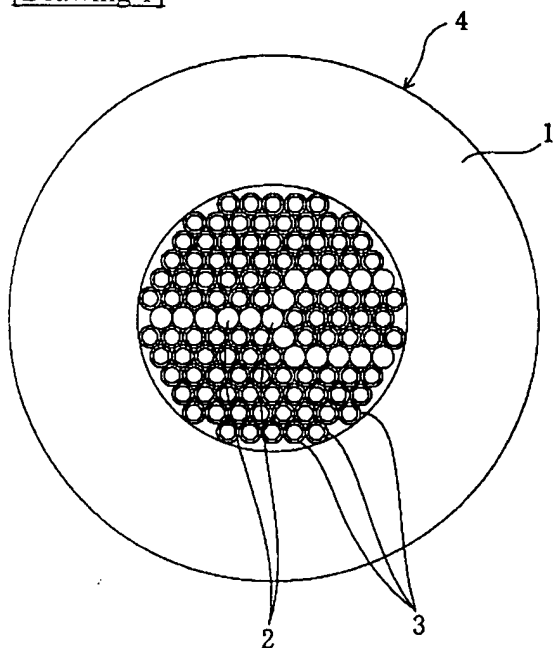
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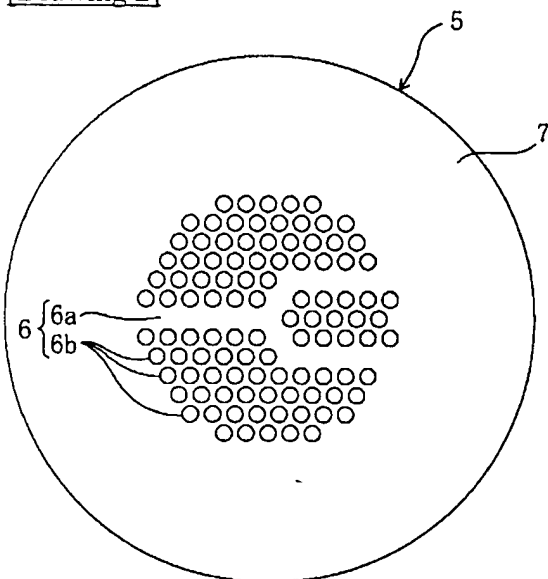
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DRAWINGS

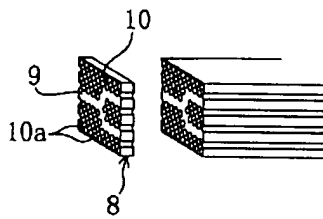
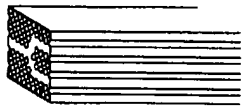
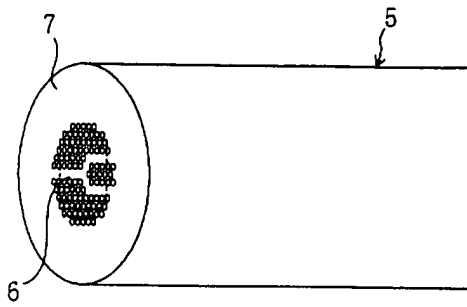
[Drawing 1]



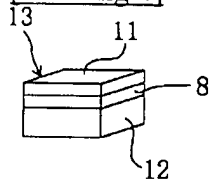
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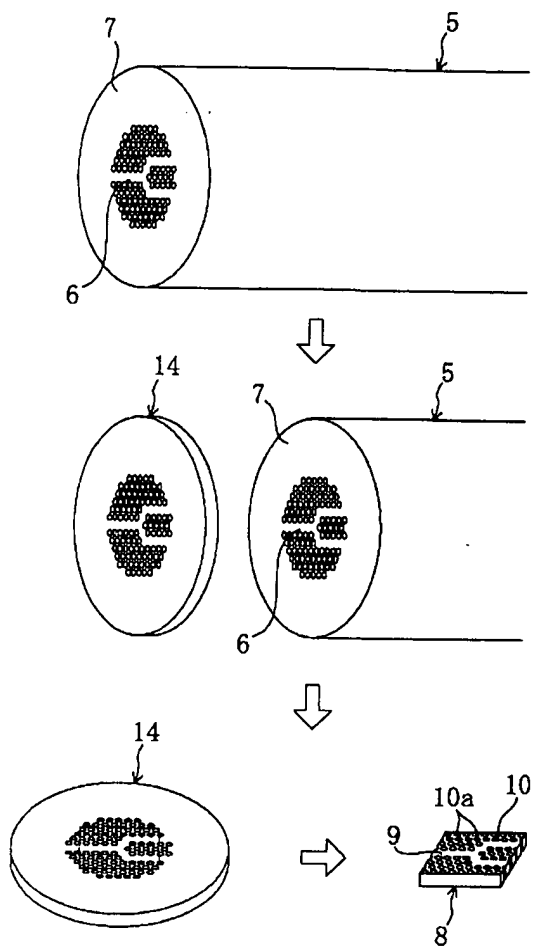
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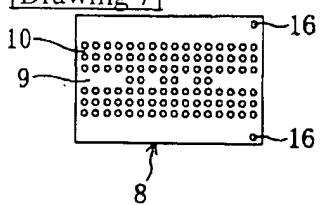
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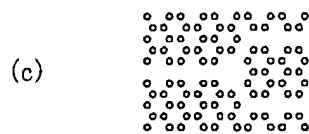
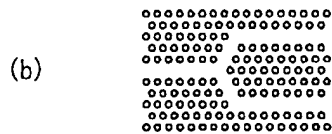
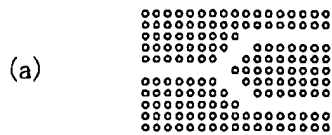
[Drawing 5]



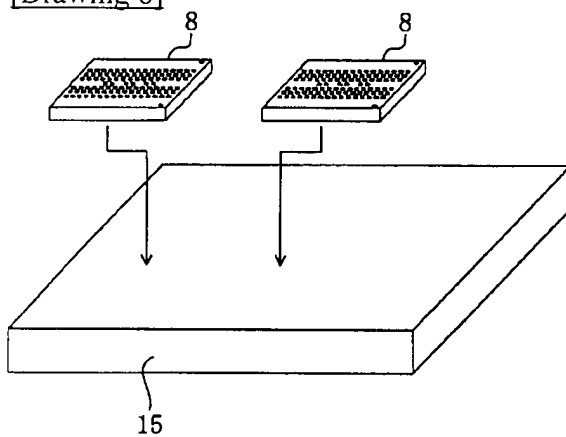
[Drawing 7]



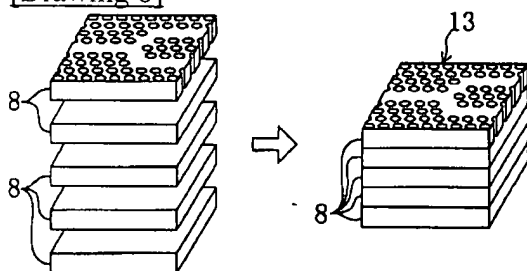
[Drawing 11]



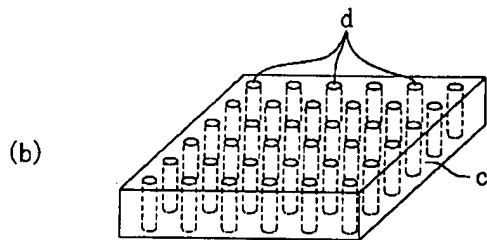
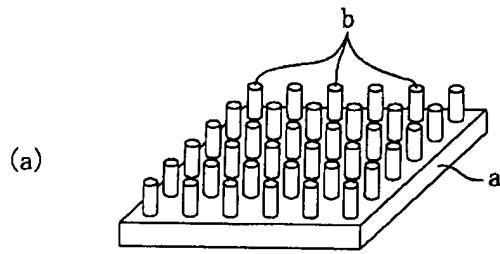
[Drawing 6]



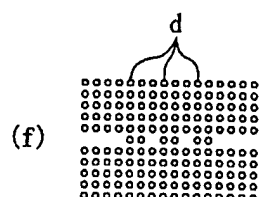
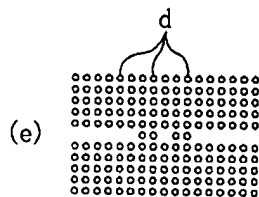
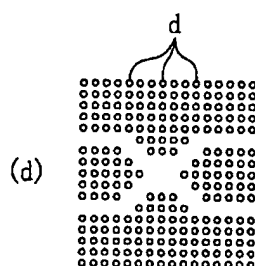
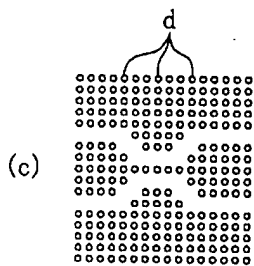
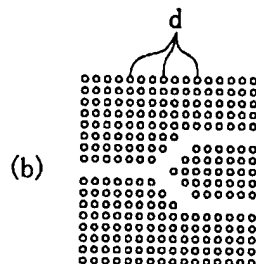
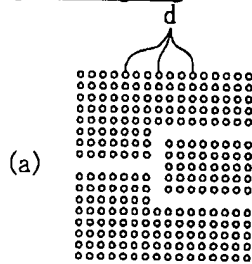
[Drawing 8]



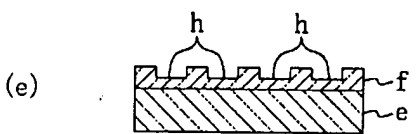
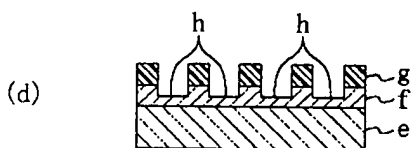
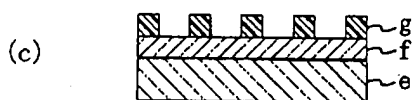
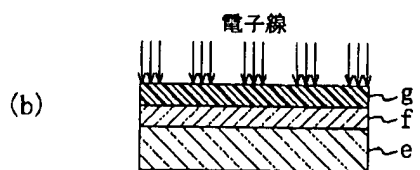
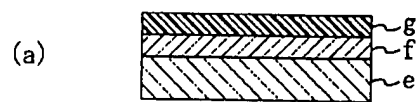
[Drawing 9]



[Drawing 10]



[Drawing 12]



[Translation done.]